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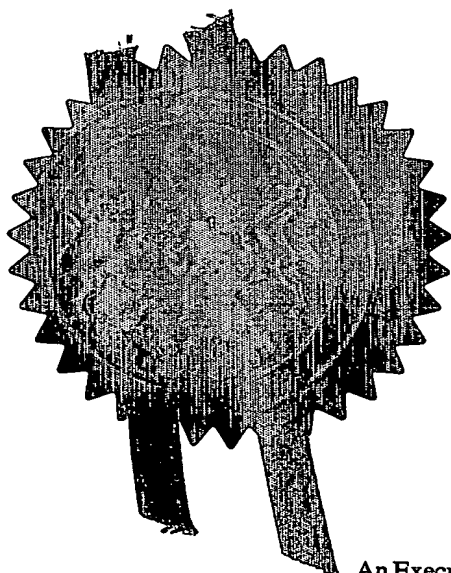
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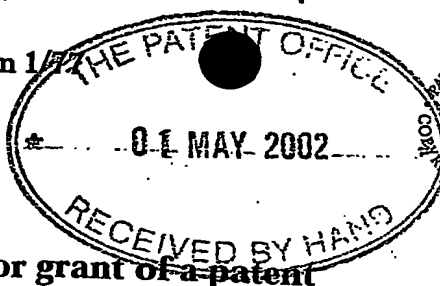
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1. Your reference

AFB/MJE/P8943GB

2. Patent application number

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0210022.0

3. Full name, address and postcode of the or of each applicant (underline all surnames)

AIR PRODUCTS AND CHEMICALS, INC.
7201 Hamilton Boulevard
Allentown
Pennsylvania 18195-1501
USA

Patents ADP number (if you know it)

5558366001

If the applicant is a corporate body, give the country/state of its incorporation

USA (Delaware)

4. Title of the invention

GAS DISPENSING AND RECOVERY APPARATUS

5. Name of your agent (if you have one)

W. H. Beck, Greener & Co.

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

W. H. Beck, Greener & Co.
7 Stone Buildings
Lincoln's Inn
London WC2A 3SZ

Patents ADP number (if you know it)

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Country

Priority application number
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Date of filing
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Number of earlier application

Date of filing
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13 ✓

Claim(s)

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Abstract

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Statement of inventorship and right to grant of a patent (Patents Form 7/77)

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11.

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Signature

Date 01.05.02

Mr Michael Ellis

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr. Michael Ellis - (020) 7405 0921

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Gas Dispensing and Recovery Apparatus

The present invention relates to a process of and an apparatus for use in containing and dispensing gas and
5 storing recovered gas.

More particularly the present invention relates to a container having two compartments divided by a flexible partition means, wherein the first compartment may be
10 charged with a fresh gas and the second compartment may be charged with recovered gas used in a process for which the fresh gas was provided, such that the pressure of recovered gas may, at least partially, provide the driving force for dispensing the fresh gas and where the recovered gas may
15 displace the fresh gas in the container. The invention further relates to a process for the dispensing and recovery of gas using such apparatus.

Containers having two compartments separated by a
20 flexible partition are known, where a first compartment contains a liquid and a second compartment contains a propellant gas.

For example, in the brewing industry a container having
25 a strong rubber or polypropylene outer jacket having a flexible internal bag of heavy gauge metal foil with a dual plastic coating is used. In use, the flexible inner bag contains beer which is dispensed via a tap or valve and the ullage space of the outer jacket is charged, via a charging
30 valve, with a propellant gas such as compressed air or carbon dioxide. Thus the pressure of gas in the ullage space drives the dispensing of the beer in the flexible bag when the dispensing valve is open.

35 US-B-5622282 (Yazawa et al) discloses a double-wall aerosol container comprising a metallic outer jacket and a generally tubular flexible inner bag for containing the

aerosol. The space between the outer jacket and the flexible inner bag provides a space in which the aerosol propellant may be charged via a charging valve at the base of the outer jacket. A housing integrates the outer jacket and the aerosol-containing inner bag with a dispensing valve mechanism such that the aerosol may be dispensed through a dispensing valve by depressing a stem; the aerosol being driven through the valve by the pressure of the propellant in the outer jacket. During manufacture, once the container has been assembled, aerosol content may be charged into the inner bag via the dispensing valve stem and then the propellant charged into the outer jacket via the charging valve.

Hypodermic injection devices, such as that disclosed in US-B-6258063, include a medication unit (a first container) which is typically made of easily deformed material such as plastic or metal foil and contains the medication to be expelled through an exiting orifice. The driving force is provided by the gas pressure in the surrounding container, generated by, for example, rapid combustion of an explosive substance. A high pressure liquid jet of medication for transdermal administration can thereby be generated.

A process for dispensing fresh gas and receiving recovered gas and an apparatus for use in such a process is desirable, particularly where the gas is a high value gas and especially where the processing apparatus to which the fresh gas is provided is in an environment where space is at a premium.

Accordingly, in a first aspect of the invention, there is provided a method of storing and dispensing a first gas for use in a process and receiving and storing a second gas, said method comprising the steps of storing the first gas in the first compartment of a container having a first compartment and a second compartment separated by a movable

gas impermeable partition, dispensing the first gas from the first compartment of the container via a gas outlet of the container; and feeding the second gas to the second compartment of the container via a gas inlet of the container, whereby a volume of the second gas displaces a volume of the first gas by movement of the partition to enlarge the second compartment relative to the first compartment.

10 In a second aspect of the invention, there is provided use of a container for storing and dispensing a gas for use in a process and receiving and storing a gas recovered from the process, wherein the container comprises a first compartment having a gas outlet and a second compartment
15 having a gas inlet, said first and second compartments separated by a gas impermeable partition, wherein said partition is moveable such as to enable the relative volumes of the first and second compartment to be varied.

20 In a third aspect of the invention, there is provided apparatus for storing and dispensing a gas for use in a process and receiving and storing a gas recovered from the process, said apparatus comprising a container, which container comprises a first compartment for containing a
25 first gas and having a gas outlet; a second compartment for containing a second gas and having a gas inlet; and a gas impermeable partition which separates the first compartment and the second compartment, wherein said internal partition is moveable such as to enable the relative volumes of the
30 first and second compartments to be varied; a processing apparatus for carrying out a process involving a gas; a dispensing conduit for feeding gas from the gas outlet to the processing apparatus; a recovery conduit for feeding gas from the processing apparatus to the gas inlet; and a
35 pumping means for pumping the gas from the processing apparatus into the second compartment.

The first gas is preferably provided to a processing apparatus from which gas may be recovered and at least a portion of the recovered gas may be fed to the second compartment.

5

The processing apparatus may be any apparatus requiring a supply of gas in order to carry out a process.

In one embodiment, the processing apparatus is a
10 cardiopulmonary bypass oxygenator or an artificial ventilator. There may be more than one processing apparatus, in which case there may be a cardiopulmonary bypass oxygenator and an artificial ventilator, the first gas being provided to either one or the other (or both) of
15 the processing apparatus at any given time.

In an alternative embodiment, the processing apparatus is a gas separation or purification apparatus, in which case the gas recovered from the processing apparatus is a
20 purified gas.

The gas recovered from the processing apparatus may be removed to a remote location for disposal, purification or further use.

25

Preferably, at least a portion of the second gas, which preferably includes gas recovered from the processing apparatus, is a component of the first gas, the first gas having been through a process of the processing apparatus.

30

The recovered gas may be analysed using an appropriate analyser such that if the recovered gas meets at least one predetermined analysed criterion, preferably a minimum content of a particular component, it is fed into the second
35 compartment of the container. Otherwise, it may be vented to atmosphere or, as an alternative, recycled through the processing apparatus.

Alternatively, the recovered gas is fed into the second compartment of the container if it meets predetermined criteria in combination, such as when a minimum content of a particular component is present and where the minimum content set depends upon the pressure in the second compartment of the container. For example, when the pressure in the second compartment approaches its upper limit, the minimum content of a particular component of the recovered gas that would lead to it being fed into the second compartment is greater than when the pressure in the second compartment is lower and the second compartment thereby has a greater remaining capacity.

The recovered gas is preferably fed into the second compartment using a pump.

In a preferred embodiment of the invention, the pressure of gas in the second compartment is maintained above 1 atmosphere absolute (0.1 MPa). This should ensure that the entire content of the first compartment may be dispensed. Optionally, if the pressure of gas falls below a predetermined level, a check valve will open and allow a further gas (preferably compressed air) to be pumped into the second compartment until the pressure exceeds the predetermined level.

Preferably the first gas comprises a high value gas which it would be beneficial to recover after use in the process. Such a gas includes the noble gases, especially xenon, krypton and neon or isotopes thereof, or stable isotopes of gases such as oxygen and carbon dioxide.

In a preferred embodiment, the first gas comprises xenon, preferably in an amount of at least about 10% by volume, more preferably at least about 30%, still more preferably at least about 50% and most preferably at least about 70% by volume. Most preferably, the first gas

comprises xenon in an amount of about 80% by volume.

The first gas preferably also comprises oxygen.

- 5 In a more preferred embodiment, the first gas consists predominantly of xenon and oxygen and preferably consists solely of xenon and oxygen.

10 In a preferred embodiment, the first gas is a mixture of xenon and oxygen for dispensing to a ventilator and to a cardiopulmonary bypass oxygenator. Preferably there should be sufficient volume of the first gas in the first compartment to fill the ventilator twice and the oxygenator once, plus an additional single fill for safety. The
15 container should therefore contain up to 20 litres of xenon/oxygen mixture at a pressure of about 3 to about 4 atmospheres absolute (about 0.3 to about 0.4 MPa).

20 Preferably the second gas comprises xenon, preferably in an amount of at least about 5%, more preferably in an amount of at least about 10%, still more preferably in an amount of at least about 50% and most preferably about 70% by volume and especially about 80% by volume.

25 Preferably the partition is a flexible inner lining or bag, which defines the first and second compartments where the second compartment is the ullage space in the container, outside the flexible inner bag. Thus, in a preferred embodiment, the container comprises a flexible inner bag
30 suitable for containing a first gas which is dispensed through the gas outlet via flow control means, e.g. a tap or valve, and the ullage space is charged through the gas inlet via, for example, a charging valve, with a gas recovered from the processing apparatus to which the first gas is fed
35 or with a propellant gas such as compressed air.

Suitably, the container may be the same as the

container used in the brewing industry and described above, in which the container has a housing a strong rubber or polypropylene outer jacket having a flexible internal bag of heavy gauge metal foil with a dual plastic coating.

5

The apparatus and method of the present invention is particularly applicable with regard to the apparatus and method of our co-pending application of even date (file reference: P8944GB) in respect of a gas circulation

10 apparatus.

The following is a description by way of example only and with reference to the accompanying drawings of presently preferred embodiments of the invention. In the drawings:-

15

Figure 1 is a cross-sectional side view of a gas cylinder for use in the present invention;

Figure 2 is a schematic diagram of the gas container of Figure 1 when attached to a process apparatus; and

20

Figure 3 is a diagrammatic representation of the use of gas container of Figure 1 in a gas recirculation apparatus for providing gas to a cardiopulmonary bypass oxygenator.

25

With reference to Figure 1, a gas cylinder (generally designated 1) comprises a fresh gas space 3 defined by inner foil bag 7 and an ullage space 5 consisting of the remaining internal volume of cylinder 1. The contents of the fresh gas space 3 are accessed via dispensing valve 9 and the ullage space 5 is accessed via inlet valve 11.

30

The fresh gas to be used is dispensed through valve 9 for use in the user's process apparatus 15 (see Figure 2). Gas used in the process apparatus 15 is directed via used gas conduit 13 to analyser 17. If the used gas does not reach a predetermined standard according to the analysis, it

35

is vented through vent 19. If the predetermined standard is reached, the gas is directed through recovery conduit 21 and pump 23 pumps the recovered gas via inlet valve 11 into the ullage space 5.

5

The fresh gas in space 3 is provided at a lower pressure than pump 23 although the system is slightly pressured at all times to ensure complete evacuation of space 3 can be achieved. If desired, the initial pressure within the container can be such as to permit some recovery of gas into the ullage space prior to dispensing fresh gas. Dispensing and recovery can be continuous or discrete depending upon whether or not gas is recycled for use in the process apparatus 15.

15

Optionally a further check valve 25 is provided to ensure a minimum pressure is provided to the ullage space 5 ensuring that the pressure of gas in the ullage space does not fall below 1 atmosphere (0.1 MPa).

20

With reference to Figure 3, a xenon/oxygen mixture in a ratio of 80% xenon to 20% oxygen is fed into the main circuit 102 of the apparatus (generally designated 101) from a xenon/oxygen supply in fresh gas space 119 of container 121 via xenon mass flow controller (MFC) 123. Container 121 is as described above with reference to and illustrated in Figure 1.

25

The oxygen content of main circuit 102 may be topped up from oxygen cylinder 125 via regulator 127 and oxygen mass flow controller (MFC) 129.

30

One or more (preferably four) diaphragm pumps 117 pump the xenon/oxygen mixture around the circuit 102 at a rate of up to 20 litres per minute (l/min) at a pressure of up to 150 millibar gauge (1150 kPa).

35

The gaseous composition is fed to cardiopulmonary bypass (CPB) oxygenator 103 via gas outlet 105, which is regulated by flow control valve 139, which may be set at a desired level by the operator.

5

CPB oxygenator 103, which is typically a membrane oxygenator, is fed unoxygenated blood from a patient 107 via unoxygenated blood conduit 109 and returned to the patient 107 via oxygenated blood conduit 111. Spent gas from the CPB oxygenator 103 is fed through gas inlet 113 and then through water trap 147, primary carbon dioxide absorber 135 and pump(s) 117.

10

Gas passing through the inlet 113 and outlet 105 pass through respective bacterial filters 115 to protect the patient 107 from contamination from the apparatus 101 and vice versa.

15

In order to ensure that a constant flow of gas at the set pressure is supplied to the oxygenator 103 and thus available to the patient's blood, excess gas is fed through bypass conduit 140 via pressure maintaining valve 141 upstream from the flow control valve 139. Pressure maintaining valve 141 is a valve which allows gas flow through the bypass conduit 140 only when the pressure exceeds a predetermined level, for example 30 mbarg (103 kPa).

20

25

Downstream from the pressure maintaining valve 141, the gaseous composition is analysed for xenon content using ultrasonic xenon analyser 143 of the kind described in our copending patent application of even date (file reference P8942GB). The gas is then fed via bellows 145, which expand to take up any additional volume of gas in the apparatus or contract to compensate for loss of volume in the apparatus, and rejoins the main circuit 102 upstream of pump(s) 117.

30

35

The oxygen concentration in the main circuit 102 is monitored by oxygen fuel cell sensor 131 situated in the main circuit 102 downstream from pump(s) 117. The gas is then fed through backup carbon dioxide absorber 133, which
5 removes residual carbon dioxide from the recirculating gas.

The carbon dioxide removed by absorbers 133 and 135 has entered via the oxygenator 103 after being flushed from the patient's blood. At least absorber 135 should be replaced with each use of the system.

10

Downstream from the backup carbon dioxide absorber 135, a small sample of gas is drawn from the main circuit and fed to analyser unit 137 to be analysed for carbon dioxide, via an infra red gas analyser, to ensure that the carbon dioxide
15 absorbers are working efficiently and for oxygen, via a paramagnetic gas analyser, as a backup to the oxygen fuel cell sensor 131. The sample is returned to the main circuit upstream from the pump(s) 117.

20

Recovery gas conduit 149 feeds spent gas from the main circuit 102 at a point downstream from the backup carbon dioxide absorber 135 to the ullage space 151 of container 121, via recovery valve 153 and compressor 155.

25

An atmospheric vent 157 from bellows 145 enables the gas within the apparatus to be vented to atmosphere if desired.

30

There is a U-tube relief device 159 on the gas inlet 113 to protect the oxygenator 103 and patient 107 in the event of any back pressure from the apparatus 101.

35

Addition of fresh gas to the apparatus is controlled by an analog electronic circuit (not shown) between oxygen fuel cell sensor 131 and oxygen MFC 129 for fresh oxygen addition and by an analog electronic circuit between an ultrasonic level sensor 146 measuring the position of the bellows and

the xenon MFC 123 for fresh xenon/oxygen mixture addition.

As well as monitoring the concentration of oxygen in the main circuit 102, oxygen fuel cell sensor 131 enables the oxygen concentration to be controlled. The operator may choose a set point on the sensor 131 corresponding to the desired oxygen concentration. If oxygen concentration measured by sensor 131 falls below the set point, oxygen MFC 129 is triggered to feed fresh oxygen into the main circuit 102 at a rate proportional to the difference between the oxygen level set point and the oxygen sensor 131 measurement via the high gain circuit connecting oxygen MFC 129 to sensor 131.

Typically, the high gain oxygen control circuit (not shown) will have a gain of 1, corresponding to an oxygen flow rate through oxygen MFC 129 and into the main circuit 102 of 1 l/min for every 1% difference between the oxygen set point and the measured oxygen level.

The xenon concentration of the main circuit is controlled by ultrasonic bellows level sensor 146. The operator may set the desired level on a potentiometer (not shown) which is connected to sensor 146, which corresponds to an expanded level of the bellows 145. This level corresponds to the volume in the system and, given that the oxygen concentration is known, to a desired concentration of xenon. When the sensor 146 detects that the bellows 145 has fallen below the desired level, xenon MFC 123 is triggered to feed fresh oxygen/xenon mixture into the main circuit 102 at a rate proportional to the difference between the potentiometer set point and the level measured by bellows sensor 146, via the low gain circuit (not shown) connecting sensor 146 to xenon MFC 123.

Typically, the xenon low gain circuit will have a gain of 0.1, corresponding to a flow of fresh xenon/oxygen

mixture into the main circuit 102 of 0.1 l/min for every 1% difference between the potentiometer setpoint and the level measured by bellows sensor 146.

- 5 The various sensor readings and flow rates are displayed on a monitoring unit (not shown).

10 In use, oxygen is consumed and replaced by carbon dioxide via the CPB oxygenator 103. The operator may select the flow rate to the oxygenator 103 by using flow control valve 139. This effectively controls the rate that carbon dioxide is flushed from patient's blood into the apparatus and hence provides some control as to the relative acidity or alkalinity of the patient 107.

- 15 Carbon dioxide is absorbed by primary carbon dioxide absorber 135 and the reduction in the oxygen level is detected by fuel cell sensor 131 triggering, via the high gain circuit, replenishment of oxygen levels under the control of oxygen MFC 129.

25 Xenon sensor 143 measures the xenon concentration in the main circuit 102. This reading may be compared to other readings to reach various conclusions. For example, if the oxygen concentration measured by oxygen fuel cell sensor 131 does not equal 100 minus the xenon concentration measured by xenon sensor 143, it is indicative of contamination, for example by carbon dioxide or nitrogen, and the operator may be alerted to vent the apparatus to atmosphere or recover the used gas. Alternatively, this may be done automatically at a preset level. The xenon sensor 143 is also used to monitor the xenon concentration predicted from the level of the bellows. Similarly, if these two readings do not agree, this may be indicative of too much carbon dioxide, nitrogen or oxygen. As a result, the operator may again choose to vent to atmosphere or recover the used gas.

If the gas volume in the apparatus is increased, the level of bellows 145 increases. If the level of bellows 145 exceeds a preset level, gas is vented from the apparatus, again either manually or automatically, via atmospheric vent 5 157 and/or xenon recovery valve 153. Optionally, the sensor 146 may be connected to ultrasonic analyser 143 so that when the bellows 145 upper level is exceeded, vent 157 or valve 153 is selectively opened depending on the xenon content of the gas measured by analyser 143.

CLAIMS

1. A method of storing and dispensing a first gas for use
in a process and receiving and storing a second gas, said
5 method comprising the steps of

storing the first gas in the first compartment of a
container having a first compartment and a second
compartment separated by a movable gas impermeable
10 partition,

dispensing the first gas from the first compartment via
a gas outlet of the container; and

15 feeding the second gas to the second compartment via a
gas inlet of the container

whereby a volume of the second gas displaces a volume of the
first gas by movement of the partition to enlarge the second
20 compartment relative to the first compartment.

2. A method as claimed in Claim 1, which further comprises
the steps of

25 providing the first gas to a processing apparatus for
carrying out a process involving the first gas;

recovering gas from said processing apparatus; and

30 feeding at least a portion of said recovered gas to the
second compartment to provide at least a portion of the
second gas.

3. A method as claimed in Claim 2, wherein at least a
35 portion of the second gas is a component of the first gas.

4. A method as claimed in Claim 2 or Claim 3, which

further comprises the steps of analysing the recovered gas and feeding to the second compartment at least a portion of the recovered gas that satisfies at least one predetermined criterion.

5

5. A method as claimed in any one of the preceding claims, wherein the pressure of gas in the second compartment is maintained above 0.1 Mpa (1 atmosphere).

10 6. A method as claimed in any one of the preceding claims, wherein the first gas comprises a noble gas, a noble gas isotope, an isotope of oxygen or an isotope of carbon dioxide.

15 7. A method as claimed in any one of the preceding claims, wherein the first gas comprises xenon.

8. A method as claimed in Claim 7, wherein the first gas comprises xenon in an amount of at least about 50% by
20 volume.

9. A method as claimed in Claim 7 or Claim 8, wherein the first gas further comprises oxygen.

25 10. A method as claimed in Claim 9, wherein the xenon and oxygen are the sole components of the first gas.

11. A method as claimed in any one of claims 7 to 10, wherein the second gas comprises xenon.

30 12. A method as claimed in any one of Claims 2 to 11, wherein the processing apparatus is a cardiopulmonary bypass oxygenator or an artificial ventilator.

35 13. Use of a container for storing and dispensing a gas for use in a process and receiving and storing a gas recovered from the process, wherein the container comprises a first

compartment having a gas outlet and a second compartment having a gas inlet, said first and second compartments separated by a gas impermeable partition, wherein said partition is moveable such as to enable the relative volumes
5 of the first and second compartment to be varied.

14. A use as claimed in Claim 13, wherein the gas impermeable partition is a flexible inner lining of the container.

10

15. Apparatus for storing and dispensing a gas for use in a process and receiving and storing a gas recovered from the process; said apparatus comprising

15

a container, which container comprises

a first compartment for containing a first gas and having a gas outlet;

a second compartment for containing a second gas and having a gas inlet; and

20

a gas impermeable partition which separates the first compartment and the second compartment and is moveable such as to enable the relative volumes of the first and second compartments to be varied;

25

a processing apparatus for carrying out a process involving a gas;

a dispensing conduit for feeding gas from the gas outlet to the processing apparatus;

30

a recovery conduit for feeding gas from the processing apparatus to the gas inlet; and

a pumping means for pumping the gas from the processing
35 apparatus into the second compartment.

16. An apparatus as claimed in Claim 15, wherein the gas

impermeable partition is a flexible inner lining of the container.

17. An apparatus as claimed in Claim 15 or Claim 16,
5 wherein the processing apparatus is a cardiopulmonary bypass oxygenator or an artificial ventilator.
18. An apparatus as claimed in Claim 17, wherein the processing apparatus is a cardiopulmonary bypass oxygenator.
- 10 19. An apparatus as claimed in Claim 18, which comprises a further processing apparatus which is an artificial ventilator and a valve for selectively directing the dispensed gas to either the cardiopulmonary bypass
15 oxygenator or the artificial ventilator.
20. An apparatus as claimed in Claim 15, substantially as hereinbefore described with reference to the drawings.
- 20 21. A method as claimed in Claim 1, substantially as hereinbefore described with reference to the drawings.

ABSTRACTGas Dispensing and Recovery Apparatus

5 A container (1) having a first compartment (3) and a
second compartment (5) separated by a movable gas
impermeable partition (7) is used for storing and dispensing
a gas for use in a process and receiving and storing a gas
recovered from the process. Fresh gas is dispensed (9) from
10 the first compartment (3) for use in a process and recovered
gas is fed (11) to the second compartment (5), whereby a
volume of the second gas displaces a volume of the first gas
by movement of the partition (7) to enlarge the second
compartment (5) relative to the first compartment (3).

15

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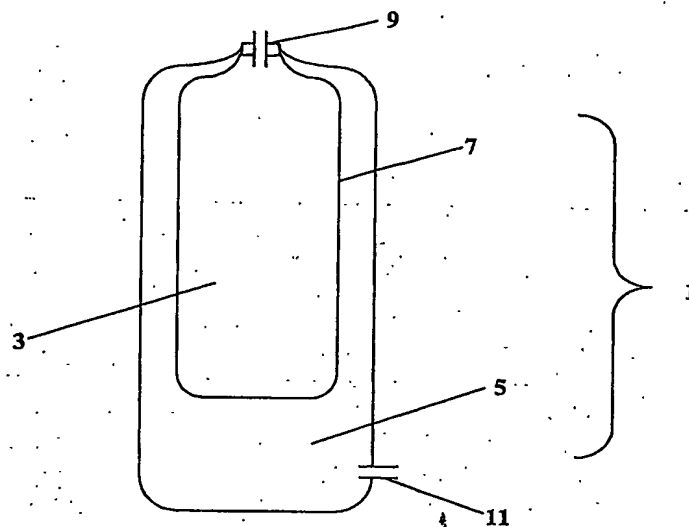


Figure 1

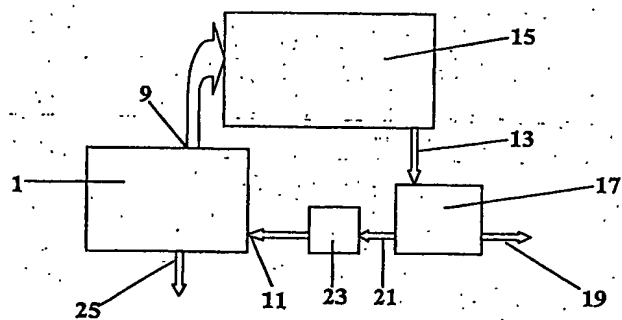
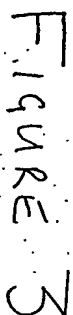


Figure 2



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